Does It Pay to Be Green? A Systematic Overview

by Stefan Ambec and Paul Lanoie

Executive Overview

The conventional wisdom concerning environmental protection is that it comes at an additional cost imposed on firms, which may erode their global competitiveness. However, during the last decade, this paradigm has been challenged by a number of analysts (e.g., Porter & van der Linde, 1995), who have argued basically that improving a company's environmental performance can lead to better economic or financial performance, and not necessarily to an increase in cost. The aim of this paper is to review empirical evidence of improvement in both environmental and economic or financial performance. We systematically analyze the mechanism involved in each of the following channels of potential revenue increase or cost reduction owing to better environmental practices: (a) better access to certain markets; (b) differentiating products; (c) selling pollution-control technology; (d) risk management and relations with external stakeholders; (e) cost of material, energy, and services; (f) cost of capital; and (g) cost of labor. In each case, we try to identify the circumstances most likely to lead to a "win-win" situation, i.e., better environmental and financial performance. We also provide a diagnostic of the type of firms most likely to reap such benefits.

Since the publication of the Brundtland Report in 1987 and the subsequent Earth Summits in Rio de Janeiro (1992) and Johannesburg (2002), sustainable development has become one of the foremost issues facing the world. It is recognized that natural systems can be especially vulnerable to human activity because of limited adaptive capacity, and some of these systems may undergo significant and irreversible damage. Furthermore, recurrent smog alerts, acid rain, holes in the ozone layer, global warming, and the loss of biodiversity are among the growing evidence that such a calamity is indeed possible—and occurring faster, in many cases, than scientists originally thought. That is why environmentalists in particular, and the general population more broadly, believe that a business-as-usual approach is worrying. This kind of concern is likely to become more pressing in the future as young generations become even more sensitive to these issues.

Managers have long associated environmental protection with additional costs imposed by government, which in turn erode a firm's global competitiveness. This view relies on a basic paradigm: In general, markets work well to reach optimal use of scarce resources, so that government intervention is useful only for redistributing revenues, or when markets are no longer fulfilling their role effectively. This is precisely what occurs in the case of environmental problems. One of the prerequisites for the adequate functioning of markets is the existence of well-defined ownership rights. In the case of environmental resources available to all, such as clean air and water, these rights are very difficult to assign. Therefore, because air and water belong to no one (or to everyone), economic agents may use them at zero cost, whereas the actual cost of this use for society as a whole is certainly greater. Polluters receive the wrong signal and, because they use these resources without paying the true price, they are encouraged to do so to excess. Left alone, the market mechanism generates too much pollution, and government intervention is legitimate to reduce it to a tolerable

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threshold. To that end, government has at its disposal a panoply of instruments, such as regulations, taxation, and pollution permits,[1] that may result in the polluters' receiving the right signal, once confronted with the true cost of their actions. In short, from this perspective, consideration of the environment is necessarily associated with a cost increase for companies that have used environmental resources with impunity. Indeed, the prevailing wisdom is that environmental concerns divert managers from their main responsibility, which should be the maximization of profit (see Friedman, 1970).

However, during the last decade, this paradigm has been challenged by a number of analysts (Gore, 1993; Porter, 1991; Porter & van der Linde, 1995). In particular, Porter argued that pollution is often associated with a waste of resources (material, energy, etc.), and that more stringent environmental policies can stimulate innovations that may offset the costs of complying with these policies. In fact, there are many ways that improving a company's environmental performance can lead to better economic or financial performance, and not necessarily to an increase in cost. To be systematic, it is important to look at both sides of the balance sheet: increasing revenues and reducing costs.

In the literature, one can find conceptual or theoretical arguments outlining seven opportunities (described in detail below) companies can make use of to either increase revenues or reduce costs while at the same time being responsible with the earth's resources (Lankoski, 2000, 2006; Reinhardt, 2000). However, to our knowledge, there has been no systematic effort to provide empirical evidence supporting the existence of these opportunities and assess their scope. In this paper, for each of the opportunities we have identified, we present the economic reasoning involved and provide a systematic review of the empirical evidence available. Furthermore, in each case, we try to identify the circumstances most likely to lead to a "win-win" situation (i.e., better environmental and financial performance) and describe the types of firms most likely to enjoy such benefits. The objective of the paper is not to show that a reduction of pollution is *always* accompanied by better financial performance, but rather to show that, in many cases, the expenses incurred to reduce pollution can partly or completely be offset by gains made elsewhere.

The rest of the paper is organized as follows: First, we sketch our basic analytical framework. Second, we review the opportunities available for improving a company's environmental performance while increasing its revenues. Third, we present the categories of cost that can be reduced through better environmental performance. Finally, we conclude with a summary and a discussion of future research.

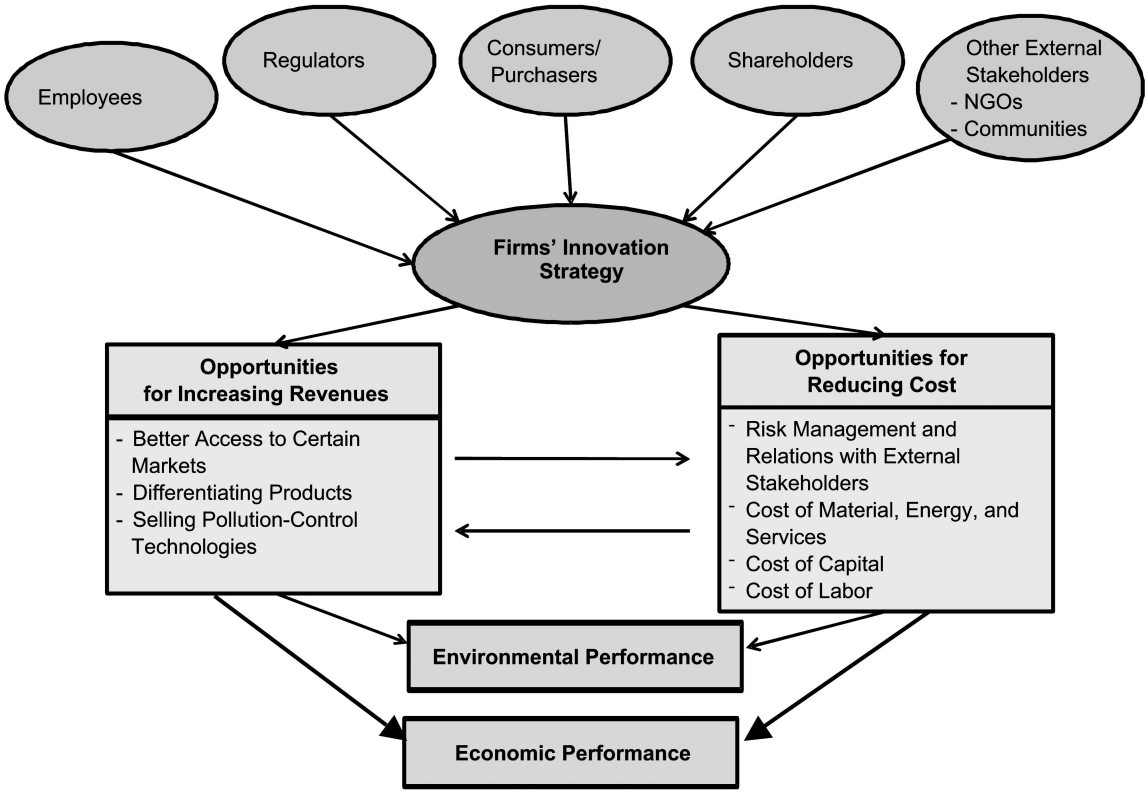
Analytical Framework

Firms are facing growing pressure to become greener. Various stakeholders (consumers/purchasers, investors, bankers, NGOs, and so on) press companies to reduce their negative impact on the environment. This is now seen as firms' social responsibility, what businesspeople often refer to as "corporate social responsibility" (Friedman, 1970; May et al., 2007). In various industries, firms must try to cope with these pressures while staying competitive. Management studies (e.g., Aupperle et al, 1985; Folger & Nutt, 1975; Levy, 1995) have argued that environmental corporate social responsibility is generally associated with a reduction in competitiveness. Yet firms can try to reduce their environmental impacts without hurting their economic performance by implementing an ambitious innovation strategy. Such an approach would include one or more of seven strategies that could result in increased revenues or reduced costs.

First, better environmental performance can lead to an increase in revenues through three channels: (a) better access to certain markets; (b) differentiating products; and (c) selling pollution-control technology. Second, better environmental performance can lead to reductions in cost in four categories: (a) risk management and relations with external stakeholders; (b) cost of material, energy, and services; (c) cost of capital; and (d)

[1] In general, it is considered that "market-based" instruments, such as green taxes and pollution permits, should be preferred over regulation, because they provide incentives for abatement cost minimization and continuous innovation.

Figure 1
Positive Links Between Environmental and Economic Performance



cost of labor. These mechanisms are summarized in Figure 1.

Interestingly, opportunities to increase revenues or reduce costs can reinforce each other, leading to the arrows between both sets of opportunities. For instance, producing greener products through a differentiation strategy may enhance workers' commitment toward a company, and this could facilitate recruiting and retaining workers. In the same vein, reducing the material or energy costs of a product may facilitate the incorporation of environmental features into the product, helping to develop a differentiation strategy.

Increased Revenues

Better Access to Certain Markets

Better environmental performance may facilitate access to certain markets. First, generally speaking, reducing pollution and other environmental impacts may improve the overall image or prestige of a company, and thus increase customers' loyalty or support sales efforts. Although this argument seems pretty straightforward, it is difficult to find strong empirical evidence that customers are influenced by a company's "green" image. Consumers may be aware of a company's environmental performance through its offer of green products, but they are less likely to be familiar with its environmental performance as measured by its emissions to water or the atmosphere.

Second, more specifically, purchasing policies of public and private organizations may reward green suppliers. It is becoming increasingly common for public administrations to include environmental performance as a criterion for choosing suppliers of goods or services. This phenomenon is known as green public purchasing (GPP). As an illustration, Kunzik (2003) reported that, in general, the central U.K. government, in its Greening of Government Operations policy, aims to:

- Encourage manufacturers, suppliers, and contractors through specifications to develop environmentally preferable goods and services at competitive prices.

- Ensure that any products derived from wildlife, such as timber, plants, and leather goods, are from sustainable sources . . . (p. 194).

More specifically, for instance, the U.K. Department of Environment, Transport, and Regions has the following objectives:

- Buy a minimum of 10% of electricity from renewable sources.
- Purchase sustainably produced timber products by, for example, specifying that suppliers provide independently verifiable documentary evidence that their timber has been lawfully obtained from sustainable forests managed "to prevent harm to other ecosystems and any indigenous people" (p. 197).

In the United States, the Federal Acquisition Regulations provide a detailed code of rules governing procurement by all federal agencies. For instance, these rules specify that "the Environmental Protection Agency (EPA) has to prepare guidelines on the availability, sources, and potential uses of recovered materials and associated products, including solid waste management services; and require federal agencies themselves to develop and implement affirmative procurement programs for EPA-designated products" (Kunzik, 2003, p. 203).

Overall, public purchasing is fairly important in the economy. In 1998, it was estimated that government-sector expenditures for consumption and investment were responsible for 20% of GDP in OECD member countries, 9% when subtracting compensation for employees (Johnstone & Erdlenbruch, 2003).[2] It can be argued that green public purchasing "can spur innovation by increasing the competitive advantage of greener products in the market, which can then be followed by larger commercialization and diffusion. In particular, public demand may provide "demonstration" effects, giving valuable information to other actors in the economy about potential benefits of newer untried green technologies and products" (p. 12).

In addition, private companies have taken steps to "green" their supply chains. Presumably, all plants with ISO 14001 certification pay attention to their suppliers' environmental performance, as this is one of the criteria to be fulfilled to obtain the certification (Barla, 2007).[3] Furthermore, a recent survey of the OECD, covering more than 4,000 facilities in seven countries, showed that 43% of them assess their suppliers' environmental performance (Johnstone et al., 2007).

Some companies' policies regarding their suppliers' green performance have been well documented in case studies. For instance, before choosing a supplier, IBM asks potential candidates to do a self-evaluation of their environmental performance, and for those that have a satisfactory score on the self-evaluation, there is an on-site evaluation of practices (Herren et al., 1998). In the same vein, since 1992 Body Shop International has had a strict evaluation system for its suppliers' environmental performance, the Supplier Environmental Star-Rating Scheme (Wycherley, 1999). Wal-Mart has developed incentive plans and "commonsense" scorecards for its merchandise buyers to encourage innovation and environmentally preferable products.[4]

Beyond these laudable efforts by companies, is there any research or empirical evidence showing that it pays firms to incur extra expense to improve their environmental performance in order to have better access to certain markets? In other words, is it profitable to be green? There is little evidence to that effect. At best, we can rely on the recent study of Hamschmidt and Dyllick (2006) who provided, to our knowledge, the first cost-benefit analysis of an implementation of ISO 14000. In many cases, companies are making the effort to comply with the ISO 14000 requirements in order to improve their image and reach extra customers (Hess et al., 1999). For their sample of 158 certified Swiss firms, they found that the

[2] According to Marron (2003), the largest private suppliers of public administration are in the following sectors: construction, energy services, transportation equipment, transportation services, shipbuilding, medical equipment, military equipment (including paper), office equipment, electrical machinery, and clothing.

[3] As of January 1, 2006, there were 103,583 plants worldwide that were ISO 14001 certified (http://www.ecology.or.jp/isoworld/english/analy14k.htm).

[4] http://www.treehugger.com/files/2006/11/walmart_introdu.php.

average payback period of the adoption of ISO 14000 was 2.2 years.

Given that most public administrations are now involved in GPP, and that a large percentage of private firms are also paying attention to their suppliers' environmental performance, it seems that firms selling to governments or other businesses (as opposed to consumers) can actually obtain better access to certain markets by improving their environmental performance.

Differentiating Products

Along the same lines, it is possible that better environmental performance through greener products or services can allow companies to use a differentiation strategy so as to exploit niches in environmentally conscious market segments. In this case, even if green products or services are more expensive to produce, the extra cost can likely be transferred to consumers who are willing to pay more for more environmentally friendly products or services.[5]

Ecolabeling can make information about the environmental features of a product or service more credible. The popularity of ecolabeling is increasing, especially in Europe. In particular, sales of products with the European ecolabel went from €51 million in 2000 to €644 million in 2004.[6] Consumers' willingness to buy green products in general is important, although the actual amounts devoted to such purchases may be less impressive. For example, 80% of French adults say they favor the purchase of ecoproducts, while 10% say they actually make such purchases regularly (Guilloux, 2006).[7]

Specific examples of enterprises that have adopted this differentiation approach are numerous. For some companies, it even became a core strategy. Among the classic examples is Patagonia, an American sport garments company, which in the 1990s launched new lines of clothing made of recycled PET (polyethylene terephthalate) and organic cotton. This was a commercial success in spite of the higher price of these products (Reinhardt, 2000). Swiss chemical company Ciba Geigy in the mid-1990s created a new type of bioreactive dye, Cibacron LS. This new dye had a higher fixation rate, which meant that less dye was required to color textiles. In turn, this meant that rinsing was simpler and less expensive, and that firms' wastewater treatment costs could be lower. In other words, this dye helped Ciba's clients reduce their environmental cost. Ciba protected this new dye via a patent. The dye was a commercial success despite its higher price (Reinhardt, 1999).

The development of the "biofood" industry (organic food producers and retailers) serves as another example of the success of this strategy, although in this case one can argue that, when buying these products, consumers are also looking at their health attributes[8]. This industry is becoming sizable; for instance, the world market for biofood products doubled between 2003 and 2006. This represents almost 8% of the world food market.[9] In Europe, the market share for biofood is estimated at 10%. Similarly, sales of organic cotton (produced without chemical fertilizers or pesticides) soared worldwide, from $245 million in 2001 to an estimated $1 billion in 2006.[10]

It is also becoming more common to see companies emerging in the "green energy" market, i.e., companies that have access to the grid to sell energy from renewable sources, such as biomass, wind, and solar. A well-documented example is the Dutch enterprise PNEM, which generates electricity from a biomass-fired power plant (Hofman, 2005).

Here again, we can ask the question: Is it worthwhile for firms to adopt this strategy? There is little empirical evidence available. FGCAQ

[5] This differentiation strategy is related to ecodesign, which refers to all the actions taken and activities carried out originating from the incorporation of environmental performance requirements in a product development project. See Johansson et al. (2001), who reported 10 ecodesign-related commercial success stories. Ecodesign can sometimes also reduce certain types of expenditures, such as the quantity of raw material used, packaging, or transportation.

[6] http://www.abgs.gov.tr/tarama/tarama_files/27/SC27EXP_EU%20Eco-label.pdf.

[7] See also Carlson et al. (1996) and Willard (2005) on the differences between "intentions" and "actions."

[8] Bonny (2006) showed that environmental attributes are almost as important as health attributes in the decision to purchase biofood in European Union countries (EU-15).

[9] http://seme.cer.free.fr/index.php?cat=filiere-bio.

[10] *Les Échos*, November 21, 2006.

(2004) and Parsons (2005) studied the profitability of farms producing organic milk compared with that of farms producing regular milk, and they concluded that there is no significant difference between the two groups in terms of profits.

From these examples, it seems that a differentiation strategy is more likely to work when[11] (a) the information about the environmental features of the product is credible (e.g., an ecolabel), (b) consumers are willing to pay for extra environmental features (this is more difficult with low-end products), and (c) there is a barrier to imitation from competitors (such as the patent obtained by Ciba). The variety of the examples available leads us to believe that a wide range of enterprises can actually achieve better environmental performance and obtain more revenues by using this strategy. Even firms producing fairly homogeneous goods that are usually difficult to differentiate, such as agricultural products or energy, can do so.

Selling Pollution-Control Technology

For decades, solving environmental problems has become a business opportunity for companies that specialize in this area—what we can refer to as the ecoindustry. A detailed description of this industry and its market structure lies beyond the scope of this paper.[12] Rather, we are interested in firms that, in their search for better environmental performance, are led to do research and development in the area of pollution-control technologies, so as to optimize their manufacturing or waste management processes. This can lead to technological breakthroughs that potentially can be attractive for others. Companies adopting such a strategy may also enjoy a "first-mover" advantage, and may eventually lobby governments for stricter regulations.

For example, as mentioned above, Ciba Geigy patented its new Cibacron LS dye that could be sold to other companies under licensing agreements. Indeed, following its experience with the new dye and wastewater treatment, Ciba in 1998 bought Allied Colloids Group, a U.K. manufacturer of water treatment additives. This was the first step in creating its environmental division. Another example of a large company that has diversified its activity by opening an "environment" division is General Electric. Its Ecomagination division includes 32 clean-technology products, such as wind turbines, and had revenues of $10 billion in 2005 and is forecasting $20 billion in 2010.[13]

In the same vein, the major aluminum producer Alcan has developed and tested a spent potlining (SPL)[14] treatment, the Low Caustic Leaching and Liming (LCLL) process. Up to now, SPL was considered a hazardous waste that had to be stored or landfilled very carefully. With its new process, Alcan will be able to recycle a large part of this waste. The company is building a new plant in Canada to treat its own and eventually other companies' SPL.

Selling pollution-control technology, as one way to turn an environmental problem into an increase in revenues, is probably not a widespread phenomenon. The three examples we found suggest that firms must already have research facilities and a large amount of resources to eventually sell a pollution-control technology they have developed for themselves.

Cost Reductions

Risk Management and Relations With External Stakeholders

Better environmental performance may make the relations between the firm and its external stakeholders (e.g., government, ecological groups, media, communities) easier and reduce the risk associated with these relations. In particular, as

[11] See also Reinhardt (2000) for more discussion.

[12] Ecoindustries are industries that produce goods and services to measure, prevent, limit, minimize, or correct environmental damage to water, air, and soil, as well as problems related to waste, noise, and ecosystems. This includes cleaner technologies, products, and services that reduce environmental risk and minimize resource use. In 2005, it was estimated that ecoindustries represented revenues of €180 billion and 500,000 jobs (http://ec.europa.eu/research/briefings/sustain-devel_en.html).

[13] http://ge.ecomagination.com/site/.

[14] "Spent potlining (SPL) is the main waste residue generated by the electrolysis process in the smelters producing aluminium. It consists of the internal lining of the pots, which is replaced after five to seven years of use. SPL is classified as hazardous waste by many jurisdictions worldwide due to its toxicity and explosive nature" (http://www.publications.alcan.com/sustainability/2005/en/pdf/alcan_sr05_web_releases.pdf).

suggested by Lankoski (2006), less pollution means lower liability costs, avoiding potentially costly litigation and fines. As a concrete example, El Bizat (2006) showed, through a survey of Canadian jurisprudence, that the implementation of a proper environmental management system (EMS), such as that recognized by ISO 14001, can be useful in proving due diligence in court in cases of illegal spills or other environmental accidents.

Better environmental performance may also allow a firm to anticipate and reduce the risk associated with future regulation. Firms could even push for tighter standards in order to enjoy a strategic first-mover advantage. For instance, it is well documented that, in the 1980s, Dupont lobbied to ban CFCs and other ozone-depleting substances, because it had the leadership in the research for substitutes (Reinhardt, 2000).

In the same vein, firms with a better environmental performance may find it easier to deal with other external stakeholders. For instance, goods that are more environmentally friendly are less likely to suffer from a boycott campaign orchestrated by ecological groups and carried out in the media. Similarly, firms with better environmental performance may obtain approvals from the government and the community more rapidly to extend the size of a new plant or build a new one. Risk management is again facilitated. Finally, learning to deal well with environmental stakeholders may have positive spillover with nongreen stakeholders such as unions or authorities responsible for workers' safety and health.

The companies most likely to benefit from these cost reductions are those that are heavily regulated and scrutinized by the public. One can include in this category firms with toxic emissions, such as the chemical and metallurgic industries, and firms with substantial pollutant emissions, such as the pulp and paper industry and the energy sector.

Cost of Material, Energy, and Services[15]

As mentioned in the introduction, Porter has suggested that pollution is generally associated with a waste of resources, raw material not being fully used, or lost energy. "Pollution is a manifestation of economic waste and involves unnecessary or incomplete utilization of resources. . . . Reducing pollution is often coincident with improving productivity with which resources are used" (Porter & van der Linde, 1995, p. 99). From this reasoning, Porter argued that more stringent and flexible environmental regulations, such as taxes and tradable permits, would be fruitful for the economy, stimulating innovations that might offset the cost of complying with these policies. This is known as the Porter hypothesis (PH). In particular, this line of reasoning implies that reducing pollution can generate a reduction of expenditures on raw material, energy, or services.

In the economic literature, the PH has been criticized for its lack of theoretical foundation (Palmer et al., 1995). It rests on the idea that firms systematically ignore profitable opportunities, in contradiction of the standard assumption of profit-maximizing firms subject to competitive market pressure. There are no reasons why regulation would actually be needed for firms to adopt profit-increasing innovations. Walley and Whitehead (1994) argued that, although win-win situations might exist by chance, they are very rare, and, given the magnitude of some investment for regulation compliance, the financial return is likely to be negative.

Recent papers have provided a basis for the PH by introducing a market failure (in addition to failure owing to pollution). Environmental regulations, which are devoted to solving the market failure resulting from the pollution externality, prove to mitigate the other market failure to the benefit of the regulated firms. Examples of such market failures include market power (Greaker, 2003; Simpson & Bradford, 1996), specific investments with contractual incompleteness (Ambec & Barla, 2005), asymmetric information within firms (Ambec & Barla, 2002), and spillovers in knowledge (Ambec & Barla, 2005; Jaffe et al., 2004) or learning-by-doing (Mohr, 2002). For instance, learning how to use energy more efficiently or exploit waste and by-products in one production plan might benefit other production plants and improve managerial expertise and, therefore, might entail knowledge spillovers among

[15] The services we have in mind here are mainly wastewater treatment, garbage collection, and use of recycling facilities.

a firm's divisions (Clemens & Douglas, 2006; Rosen, 2001). Yet such innovation policy might not have been implemented without regulation, owing to organizational failures such as asymmetric information between divisions.

Given the objective of this paper, it is relevant to review the rapidly growing empirical literature on the PH. We distinguish between two broad sets of studies. A first set estimates the impact of environmental regulations on the firm's innovation policy and technological choice measured by investment in R&D or in capital and new technologies or by successful patent applications. These studies test the first premise of the PH that more stringent environmental regulations enhance innovation. Yet more innovation is a necessary but not sufficient condition for the PH. Therefore, they can only invalidate or provide some support for the mechanism underlying the PH without directly testing it. In the second set of studies, the impact of environmental regulations is estimated on measures of firms' performance, such as productivity and costs. The aim is to test whether more stringent environmental policies can be beneficial to the firms. Yet those papers are silent on the process that leads to higher productivity. Ambec and Lanoie (2007) summarized several empirical papers that fit into these two sets.

In the first set of papers, Jaffe and Palmer (1997) estimated the relationship between total R&D expenditures (or the number of successful patent applications) and pollution abatement costs (a proxy for the stringency of environmental regulations). They found a positive link with R&D expenditures (an increase of 0.15% in R&D expenditures for a pollution abatement cost increase of 1%), but no statistically significant link with the number of patents. Restricting themselves to environmentally related successful patents, Brunnermeier and Cohen (2003) found a positive but small relationship with environmental regulations. Both studies suggest a weak but positive link between better environmental performance (through better compliance with regulations) and the firm's innovation policy.

For the firm's technological choices, Nelson et al. (1993) found that air pollution regulations significantly increased the age of capital in U.S. electric utilities in the 1970s. Gray and Shadbegian (1998) found that more stringent air and water regulations have a significant impact on paper mills' technological choice in the U.S. However, their results suggest that this tends to divert investment from productivity to abatement, consistent with the standard paradigm.

The second set of studies has a long tradition in the economic literature (see Jaffe et al., 1995, for a review). Most papers reviewed in Jaffe et al. (1995) highlighted the negative impact of environmental regulations on productivity. For instance, Gollop and Roberts (1983) estimated that SO_2 regulations[16] slowed productivity growth in the U.S. in the 1970s by 43%. More recent papers find more positive results. For example, Berman and Bui (2001) reported that refineries in the Los Angeles area enjoyed significantly higher productivity than other U.S. refineries despite more stringent air pollution regulations in the area. Similarly, Alpay et al. (2002) estimated that the productivity of the Mexican food processing industry was increasing under pressure from environmental regulations. They therefore suggested that more stringent regulations are not always detrimental to productivity.[17]

Relying on an extensive survey from OECD, Lanoie at al. (2007) tested the full causality chain of the PH (from environmental regulations to R&D, and then to business performance). They found that environmental regulation stringency affects R&D spending positively. Yet it has two impacts on business performance: a negative direct impact and a positive indirect impact through environmental R&D, in the spirit of the PH. The net impact of environmental regulations on business performance is nevertheless negative.

Although the mentioned studies tend to reject the PH, one cannot conclude that being green harms the firm. Concerning this research, two caveats are worth mentioning. First, it may be

[16] The regulations implemented to reduce sulfur dioxide emissions from coal power plants (see Burtraw, 2000, for details).

[17] In the same vein, Hoglund Isaksson (2005) looked at the impact of a charge on nitrogen oxide emissions introduced in Sweden in 1992 on 114 combustion plants. Her findings suggest that extensive emission reductions took place at zero or very low cost, and that effects of learning and technological development in abatement were present during the period analyzed.

argued that previous studies have not properly allowed for the dynamic dimensions of the PH. Porter argued that more stringent environmental policies will lead to innovations to reduce inefficiencies, and this in turn will eventually reduce costs. This process may take some time. In previous studies on the determinants of productivity, researchers have regressed productivity at time 0 on proxies of environmental regulation stringency at time 0 as well, which allows no time for the innovation process to occur. By introducing lags of three or four years between changes in the severity of environmental regulations and their impact on productivity, Lanoie et al. (2008) found that more severe regulations led to modest gains in productivity in a sample of 17 Quebec manufacturing sectors. Furthermore, they showed that this effect is greater in industries highly exposed to outside competition.

Second, most studies rely on command-and-control regulatory instruments, such as pollution standards, while environmental regulations are moving to more efficient "market-based" instruments, such as tradable emission permits. The economic theory predicts that emission markets reduce compliance costs by assigning those costs where they are lower. In contrast to standards (that might not be binding after a while), market-based instruments provide constant incentives to innovate. The PH is therefore more likely to be satisfied in industries regulated with the new market-based instruments, especially tradable emission permits.

In this vein, Burtraw (2000) provided evidence that the 1990 switch in environmental regulation of SO_2 emissions in the U.S. from a technological standard with emission caps to an allowance trading program considerably reduced compliance cost (40% to 140% lower than projection). It indeed not only enhanced innovation, but also fostered organizational change and competition on the upstream input market. The program left enough flexibility for the firms to select the best strategy for reducing emissions, including a switch to coal with lower sulfur content. The industry also experienced innovation in fuel blending and in the scrubber market.[18] In addition, the switch from a technological standard to tradable emission allowances led to a transfer of responsibility from engineers or chemists, typically in charge of environmental issues, to top executives such as financial vice presidents, who are trained to treat SO_2 emissions allowances as financial assets.

Even if the PH cannot be generalized to the "whole" economy, it is clear that some firms have been able to reduce emissions and costs at the same time. Let us mention a few examples. First, Dow Chemicals is well known for its WRAP (Waste Reduction Always Pays) Award program, which was implemented in 1986. "Since the program began, Dow has given the WRAP Award to 395 projects. Worldwide, the projects account for the reduction of 230,000 tons of waste, 13 million tons of wastewater, and 8 trillion BTUs of energy. The (net) value of all these projects totals roughly $1 billion."[19] Second, when implementing ISO 14001, the authorities of GM's Flint, Michigan, plant realized that they were using a lot of energy during weekends when the machines were stopped (448,918 kWh during the 1999 Thanksgiving holiday). Shutdown efforts were made very systematically so as to generate savings of approximately $250,000 per year (174,299 kWh were used during the same holiday two years later) (El Bizat, 2006). Third, examples can be found even in the services industry; five changes have been made recently at the headquarters of Adobe Systems (ranging from automatic faucets to motion sensors), which involved an initial investment of around $250,000 for annual savings of around $246,000 (*Fortune*, 2006). Fourth, Kats (2003) showed with a sample of 33 green buildings that the financial benefits of green design are more than 10 times the additional cost associated with building green. Currently, there is a movement toward "eco-efficiency," which implies that many changes can be both *eco*nomical and *eco*logical at the same

[18] The former "command and control" did not provide incentives to increase SO_2 removal by scrubbers from more than the 90% (for high-sulfur coal) or 70% (for low-sulfur coal) standard. With the new program, the incentives are such that upgrading of existing scrubbers through improvements is likely to occur.

[19] http://www.dow.com/commitments/studies/wrap.htm.

time.[20] Lanoie has collected more than 50 examples over the last eight years of companies that were able to reduce both pollution and the cost of resources, energy, and services (Lanoie & Tanguay, 2000, 2004). These companies are very diversified in terms of size, origin, and industry. The actions taken to reach these win-win outcomes are also fairly diversified (reuse of waste, use of waste as a source of energy, more efficient production technology, more efficient energy use, etc.), and this suggests that the set of potential opportunities is fairly broad.

It is not always possible to reduce both pollution and the cost of energy, material, and services, but the set of opportunities to do so seems relatively large. These opportunities are more likely to emerge in firms where the production process is flexible, and in industries where market-based instruments (such as pollution taxes and tradable permits) are implemented.

Cost of Capital

It is also possible that better environmental performance can be associated with a lower cost of financial capital. First, it is becoming quite clear that greener firms have easier access to capital markets through the proliferation of all the green (or ethical) mutual funds.[21] Through these funds, green investors can be sure that their money will be invested in firms that meet certain criteria, such as the existence of a proper environmental management system (EMS) or the absence of environmental litigation. Socially responsible investment (SRI) is becoming an important phenomenon. Assets in U.S. socially screened funds increased by 258% between 1995 and 2005, a rate of growth faster than the average of other professionally managed U.S. funds. In France, the increase was 92% between 2002 and 2006. In 2005, nearly one out of every 10 dollars (9.4%) under professional management in the U.S. was involved in SRI (10% to 15% in Europe).[22] Portfolio analysis allows one to compare the performance of these socially screened funds with that of conventional funds, as we will see below.

Second, firms with better environmental performance can borrow more easily from banks. Most banks now have a team of experts to evaluate the environmental performance of possible borrowers, in particular the size of potential liabilities owing to contaminated assets.[23] Furthermore, about 40 international banks have now adopted the Equator Principles to make sure that the projects they finance are developed in a socially responsible manner and reflect sound environmental management practices.[24]

Third, shareholders in general may be influenced by information on the environmental performance of companies, and their reactions can be perceptible on the stock market. These movements may in turn influence the cost of capital. A large number of empirical studies have tried to identify the stock market reaction to news on environmental performance. Three main approaches are dominant in that literature: (a) portfolio analyses, (b) event studies, and (c) long-term studies using regression analysis. In each case, we will present the methodology used, the main conclusions, and the limitations.

Portfolio Analysis[25]

Portfolio analysis is used to examine whether SRI funds (or indices) exhibit different performance from funds in a more general investment context. Such analysis compares the economic perfor-

[20] According to the World Business Council for Sustainable Development, there are seven principles for eco-efficiency: (a) reduce the material intensity of goods and services, (b) reduce the energy intensity of goods and services, (c) reduce toxic dispersion, (d) enhance material recyclability, (e) maximize sustainable use of renewable resources, (f) extend product durability, and (g) increase the service intensity of goods and services. See http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MTgwMjc, or Orsato (2006).

[21] In general, environmental performance is one of the criteria used to select firms in an ethical mutual fund.

[22] http://www.socialinvest.org/resources/sriguide/srifacts.cfm.

[23] For instance, the French bank BNP Paribas has a team of 120 professionals in the area of sustainable development (http://www.bnpparibas.com/en/sustainable-development). Similarly, the American Citibank reported that, in 2004 and 2005, more than 1,500 of its employees were trained on environmental issues (http://www.aeca.es/comisiones/rsc/biblioteca_memorias_rsc/informes_empresas_extranjeras_4/citigroup_2005.pdf).

[24] www.equator-principles.com. One can also refer to the Enhanced Analytics Initiative (EAI), in which members agree to use part of their budget to reward brokers who publish research on extrafinancial issues such as climate change or brand management (http://www.enhancedanalytics.com).

[25] See also the discussion in Rennings et al. (2006) and Plinke and Knorzer (2006).

mance of portfolios consisting of companies with a higher environmental or social performance with portfolios of companies that have not been screened with these criteria. The comparison is done using such indicators as Jensen's alpha and Sharpe and Treynor ratios.[26] In general, it is expected that ethical funds will underperform over the long run because fund managers are constrained to a subset of the market portfolio.

We came across 16 studies of this type, which are summarized in Ambec and Lanoie (2007).[27] Eleven of them came to the conclusion that there is no statistically significant difference between the performance of SRI funds and conventional ones, while five of them showed results confirming that SRI funds outperform conventional ones. However, the weaknesses of these studies should be noted. First, the financial success of existing funds depends heavily on the ability of fund management. Portfolio studies cannot easily separate these management effects from social or environmental performance effects. Second, in these analyses, only the average performances of funds are compared. Consequently, the specific form of the influence of environmental performance on economic performance can hardly be separated from other influences such as management of the fund, capitalization, and regional peculiarities. The identification of specific effects requires econometric methods that include all control variables besides the variable of interest (environmental performance).[28]

Event Studies

The event-study methodology is based on the assumption that the capital market is sufficiently efficient to reflect the impact of all new information (events) on the future expected profits of firms (see Fama et al., 1969). The reaction to the announcement of an event is obtained by predicting a "normal" return for each firm during an "event window" (usually the day prior to the event, the day of the event, and a few days after the event), and then subtracting this predicted normal return from the actual return observed on those days of the event window. If there is a significant difference between the predicted return and the observed return (i.e., an abnormal return), one can conclude that the event had a significant influence on the stock price. Normal returns are usually predicted using a version of the Capital Asset Pricing Model (CAPM).

Many researchers have examined the effects of environmental "events" on stock market performance. The events considered generally have the character of negative news, such as information about illegal spills, prosecutions, fines, or the emission data related to the American Toxics Release Inventory (TRI). Only a few studies consider the effects of positive news, such as information on environmental awards (Klassen & McLaughlin, 1996; Yamashita et al., 1999). Some authors, such as Blacconiere and Patten (1994), Jones et al. (1994), and White (1996), have considered only one major event, such as the Bhopal explosion or the Exxon Valdez oil spill. We surveyed 14 event studies, which are summarized in Ambec and Lanoie (2007).[29] All of them show that stock markets react significantly to good or bad environmental news. Actually, the average daily abnormal returns for bad news represents a loss of 2.22%.

Event studies offer strong econometric results of causality when they are limited to one or at most five trading days after the event to ensure that news of confounding events does not interfere with the effect of interest. Can we conclude from such results that poor environmental performance leads to an increase in the cost of capital? The potential reaction of capital markets to new information on companies' environmental impact can actually be explained by two basic scenarios.[30] In the first one, new information on liabilities (potential litigation or fine) or cleanup costs enters the market at time *t*, causing the stock price to

[26] For more details, see Bauer et al. (2005).

[27] http://www.hec.ca/iea/cahiers/2007/iea0704_planoie.pdf. See page 17 for a summary table.

[28] Bauer et al. (2005, 2007) partly overcame this difficulty through the use of Carhart's (1997) multifactor performance attribution approach. They also concluded that "any performance differential between ethical mutual funds and their conventional peers is insignificant."

[29] http://www.hec.ca/iea/cahiers/2007/iea0704_planoie.pdf. See page 21 for a summary table.

[30] This part of the presentation is based on Koehler (2006).

drop because investors expect reduced earnings and dividend payments. The return is unchanged if the fundamentals of the company do not change. This is the cash flow news effect, and its existence can be tested using the event-study methodology.

Such a short-run negative price movement does not, however, mean that the price of capital is going up. Such price changes do not provide enough substance to formulate buy/sell strategies unless we believe environmental performance to be a matter for day traders constantly arbitraging. We can thus turn to the second scenario, the "green investor effect"[31] that may come about through SRI. Learning about bad environmental news, these investors may worry about the quality of the management of the companies involved and decide to sell "dirty" stocks, which reduces their price. Investors' green preferences are likely to be more long-lived, and thus require multiperiod analyses to be well investigated (using panel data and regression analysis for instance). In this second scenario, as the price of "dirty" stocks falls, investors will demand compensation with a higher return; therefore, the cost of capital for such companies will increase, and it will be more difficult to raise new funds. In the context of our discussion on the impact of better environmental performance on the cost of capital, it will be crucial to find out which of these two scenarios dominates.[32]

Long-Term Studies Using Regression Analysis

In these studies, investigators examine, through regression analysis, the relationship between certain characteristics of companies (including their environmental performance) and their financial performance. In contrast to event studies, the analysis concentrates on characteristics of companies and not on specific news about the companies. In contrast to portfolio analysis, researchers examine not a portfolio of stocks, but single stocks. We identified 12 studies in this category, which are summarized in Ambec and Lanoie (2007).[33] Different measures of economic performance (Tobin's Q,[34] return on assets, return on sales, return on equity) and environmental performance (TRI emissions, ISO 14001 certification, the adoption of other international environmental standards) were used in the various studies. Nine studies showed that better environmental performance is associated with better economic performance. Two studies showed no impact, while one concluded that a negative relationship exists. Generally speaking, one can say that these results suggest that bad environmental performance is associated with lower economic performance on a long-term basis, and this implies an increase in the cost of capital.

Overall, what can we conclude from this extensive literature regarding the impact of better environmental performance on the cost of capital? It seems clear that a large majority of the portfolio analyses, event studies, and long-term studies show that better environmental performance is associated with better financial performance (or at least not worse). As we have discussed, the long-term studies are the most reliable, and they offer converging evidence to support the hypothesis that lower environmental performance leads to lower financial performance, and thus to a higher cost of capital.

Furthermore, it is clear that, in day-to-day life, banks (and insurers) examine the environmental performance of their clients and adjust lending conditions according to that performance. It is also evident that green or ethical mutual funds are becoming more popular, and this is providing green firms with better access to capital. Thus, we

[31] Heinkel et al. (2001) demonstrated that the number of green investors is key to affecting stock prices as in the second scenario. They designed an equilibrium model of capital markets assumed to be efficient with two types of risk-averse investors: neutral investors with low sensitivity to environmental concerns and green investors. These investors were faced with opportunities to buy more or fewer "dirty" stocks. After conducting sensitivity analysis on various parameters, they found that a key determinant of the environmental performance of companies is the fraction of green investors. They concluded that it is necessary to have at least 25% green investors to change corporate environmental investment strategy.

[32] Other limitations of the event-study methodology have been recognized. For instance, McWilliams and Siegel (1997) and McWilliams et al. (1999) have noted various methodological concerns. They criticized the use of the CAPM model, which is often chosen to predict normal returns. They also questioned the assumption of investors' rational expectations, arguing that investors could be biased.

[33] http://www.hec.ca/iea/cahiers/2007/iea0704_planoie.pdf. See page 25 for a summary table.

[34] Tobin's Q is the ratio of the market value of a firm divided by its replacement cost.

can conclude that there is strong evidence that better environmental performance does not lead to an increase in the cost of capital. In fact, there is some relatively convincing evidence that better environmental performance leads to a reduction in the cost of capital. Large firms with shares exchanged on the stock markets are more likely to benefit from these gains.

Cost of Labor

Some authors have also argued that better environmental performance can lead to a reduction in the cost of labor. As stated by two Ciba Geigy managers: "An improved image of the company results in an improved atmosphere in the workplace and hence in higher productivity. . . . People who feel proud of the company for which they work not only perform better on the job, but also become ambassadors for the company with their friends and relatives, enhancing goodwill and leading to a virtuous circle of good repute. Of course, this is impossible to quantify, but it seems clear that it is true. . . . This is especially important in recruiting talented young scientists, managers, and engineers, many of whom . . . simply would not work for a company with a poor social and environmental reputation. . . . No one wants to work for a dodgy company, and the brightest people obviously have a choice" (Reinhardt, 1999, p. 11). Similarly, De Backer (1999) provided anecdotal evidence that ISO 14001 has significant effects on employees' morale and productivity, much more than ISO 9000 certification.

If this is the case, better environmental performance can indeed reduce the cost of labor by reducing the cost of illnesses, absenteeism, recruitment, and turnover. A few analysts (e.g., Lankoski, 2006) have put forward this argument in favor of labor cost reduction. Even if the argument is fairly compelling, to our knowledge there is no direct empirical evidence supporting it. However, indirect evidence exists from surveys indicating that companies are aiming at better environmental performance to improve the satisfaction of their employees and unions. For instance, Henriques and Sadorsky (2007) found that workers' pressure is a significant determinant of a firm's commitment toward a better environment (e.g., implementation of an EMS). Grolleau et al. (2009) showed that improving human resource management is a significant motivation behind the decision to obtain the ISO 14000 certification.

What types of companies could potentially achieve labor cost reductions associated with better environmental performance? Basic intuition suggests the following: (a) companies whose emissions can affect their workers' health; (b) companies that seek to attract young, well-educated workers, such as scientists, MBAs, and engineers; and (c) companies located in areas where sensitivity to environmental concerns is more acute (e.g., the West Coast of North America).

Conclusion

The conventional wisdom about environmental protection is that it is an extra burden imposed on companies by government. However, during the last decade, this paradigm has been challenged by a number of analysts who have suggested ways in which improving a company's environmental performance can be associated with better economic performance. The objective of this paper was not to show that a reduction of pollution is *always* accompanied by better economic performance, but rather to show that the expenses incurred to reduce pollution can be partly or completely offset by gains made elsewhere. Through a systematic examination of all the possibilities, we also tried to identify the circumstances most likely to lead to a "win-win" situation. These circumstances are summarized in Table 1, in which we introduce examples for each of the seven opportunities to illustrate our point.

Table 1 allows us to have in mind a taxonomy of the firms most likely to benefit from better environmental performance. For instance, an energy company located on the West Coast of the United States and selling part of its production to public authorities is very likely to make a financial gain from an improvement in its environmental performance. However, farms, which in general are less scrutinized by regulators, sell homogeneous products, are not on the stock market, and have few employees, may be less likely to benefit

Table 1
Summary of Positive Links Between Environmental and Economic Performance

Opportunities for Increasing Revenues	Circumstances Making This Possibility More Likely	Examples
1) Better access to certain markets	More likely for firms selling to the public sector (construction, energy, transportation equipment, medical products, and office equipment) and to other businesses.	The Quebec government now cares about the environmental performance of all vehicles it buys, not only about the price.
2) Differentiating products	More likely when there is: a) Credible information about the environmental features of the product b) Willingness-to-pay by consumers c) Barrier to imitation. Wide range of possibilities.	Toyota has announced that all its models will be available with hybrid engines in 2012.
3) Selling pollution-control technologies	More likely when firms already have R&D facilities.	Alcan has patented a process to recycle its own spent potlining, and that of other companies.
Opportunities for Reducing Costs		
4) Risk management and relations with external stakeholders	More likely in industries that are highly regulated and scrutinized by the public, such as chemical, energy, pulp and paper, metallurgy, etc.	Statoil injects 1 million tons of CO_2 a year beneath the seabed of the North Sea, thus avoiding the Norway carbon tax.
5) Cost of materials, energy, and services	More likely when: a) Firms have a flexible production process b) Firms are in highly competitive industries where optimization of resources is important c) Firms are in industries where market-based environmental policies are implemented d) Firms already have R&D facilities.	BP has reduced its emissions of GHGs 10% below their level in 1990 at no cost by implementing an internal tradable permit mechanism (see Reinhardt, 2001).
6) Cost of capital	More likely for firms with shares exchanged on stock markets.	The stock value of Exxon went down by $4.7 billion following the wreck of the Exxon Valdez.
7) Cost of labor	More likely for: a) Firms whose emissions may affect their workers' health b) Firms that seek to attract young, well-educated workers c) Firms located in areas where sensitivity to environmental concerns is important.	A 2004 survey of Stanford MBAs found that 97% of them were willing to forgo 14% (on average) of their expected income to work for an organization with a better reputation for corporate social responsibility.

from better environmental performance (Lanoie & Llerena, 2007).

Implications for Future Research

As we have seen, there has been significant recent research on the topic of green profitability. However, in many areas, extra effort would certainly be welcome. Regarding opportunities to increase revenues while improving environmental performance, more cost-benefit analyses from a company point of view of strategies to differentiate products are needed. Are the extra costs of producing greener products worth the benefits of reaching new niches of environmentally conscious consumers? Furthermore, we found very few examples of firms being able to sell pollution-control technologies that they developed for their own purposes. More empirical work, digging into licensing agreements for instance, would help provide a clearer picture of this issue.

Regarding opportunities to reduce costs, impacts of better environmental performance on the cost of capital and the cost of labor should be better investigated. For instance, one difficulty with the studies on the link between environmental performance and financial performance is determining the direction of the causality. A first plausible mechanism is that environmental per-

formance leads to changes in financial performance, as postulated in the studies discussed above. Second, the direction of the causality may be reversed; profitable enterprises can afford to invest in environmental performance. Third, there may be another omitted factor, influencing both environmental and economic performance, that is responsible for the apparent statistical relationship. Apart from Wagner et al. (2002), very few attempts have been made to tackle the question with simultaneous equation models. Another possible criticism is the common use of the TRI as an indicator of environmental performance. In particular, TRI does not provide any information about emissions of nontoxic substances (such as carbon dioxide), or through energy or material use.

To provide empirical evidence of labor cost reductions associated with less pollution, one would need a database including observations on proxies of labor cost, such as turnover rates and absenteeism, and data on environmental performance. We are not aware of any database that includes all of these elements, so a new survey would have to be designed to test this hypothesis. Such an exercise would certainly be helpful.

Lastly, from a sustainable development perspective that is oriented toward a triple bottom line (economic, environmental, and social), it would also be interesting to examine the social performance of firms and its relationship to economic performance.[35] We have deliberately tried to avoid mixing environmental and social performance, although in certain areas, such as ethical mutual funds, this is almost impossible. This is a difficult topic, since there is no clear consensus on the measurement of social performance, but, given the importance of sustainable development in the minds of politicians, NGOs, and academics, it is certainly worth making the effort.

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[35] See in particular Margolis and Walsh (2001) and UNEP (2001).

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